Rete Ottica GARR-T
Realizzazione e Sviluppi

Matteo Colantonio
GARR – Gruppo Rete Ottica

WORKSHOP GARR 2022
NET MAKERS

Outline

Realizzazione

- Architettura
- Tecnologia
- Topologia
- Avanzamento

Sviluppi

- Nodi Satellite
- Spectrum Sharing
- Quantum Key Distribution

Obiettivi

Terabit/s

Programmabilità e Automazione

Capillarità

Evoluzione gestione e monitoraggio

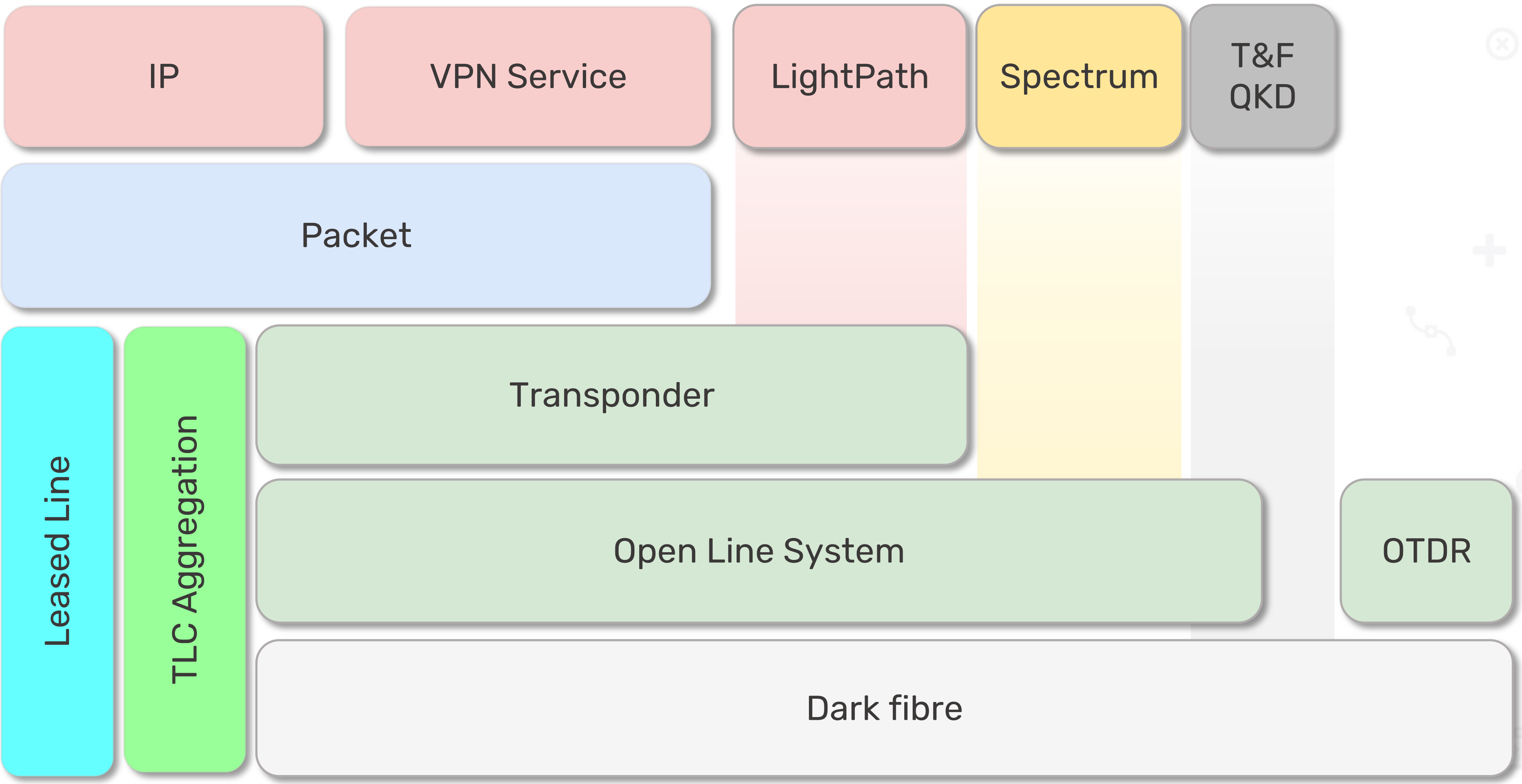
Resilienza

Evoluzione servizi

Ottimizzazione uso risorse

Minore impatto spazi e consumi

Architettura

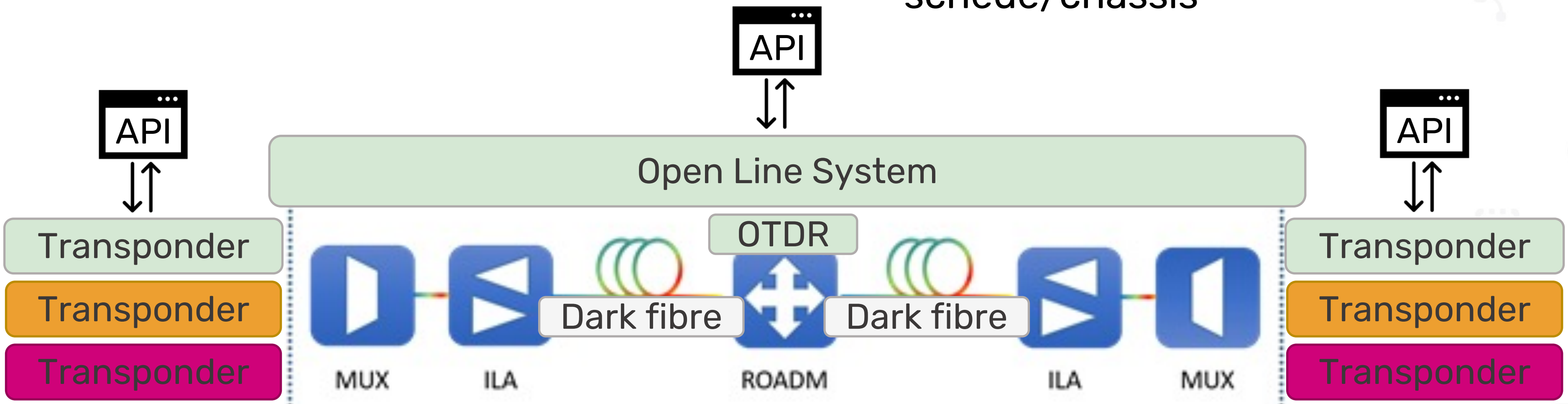


Architettura

Rete ottica parzialmente disaggregata gestibile tramite API standardizzate

Line system
- ciclo di vita ~10 anni
- singolo vendor
- aperto a segnali alieni

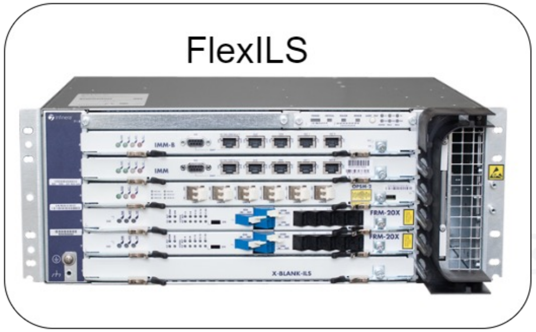
Trasponder
- multi-vendor
- Gbps/λ raddoppia in 3.5 anni
- pluggable 4 anni dopo schede/chassis



API = Application Programming Interface   ROADM = Reconfigurable Optical Add and Drop Multiplexer
ILA = In-Line Amplifier   OTDR = Optical Time-Domain Reflectometry

Tecnologia

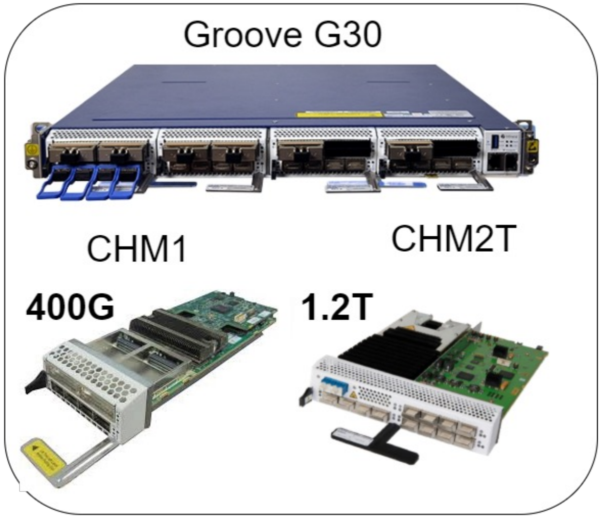
Open Line System



Line System

- FlexGrid wavelength switching con granularità di 6.25 GHz
- Extended C-band 4.8 THz
- Scalabile (ROADM a C a CDC)
- Open Line System (OLS)
- OTDR integrato

Data Center Interconnect



Transponder

- Fino a 2.4 Tbps per RU
- Interfacce client 100 e 400 Gbps
- gRPC, RESTCONF, OpenConfig

Network Management System

- FCAPS
- ONF Open Transport API

ROADM = Reconfigurable Optical Add and Drop Multiplexer C = colorless
CDC = colorless, directionless, contentionless OTDR = Optical Time Domain Reflectometry
FCAPS = Fault, Configuration, Accounting, Performance, Security

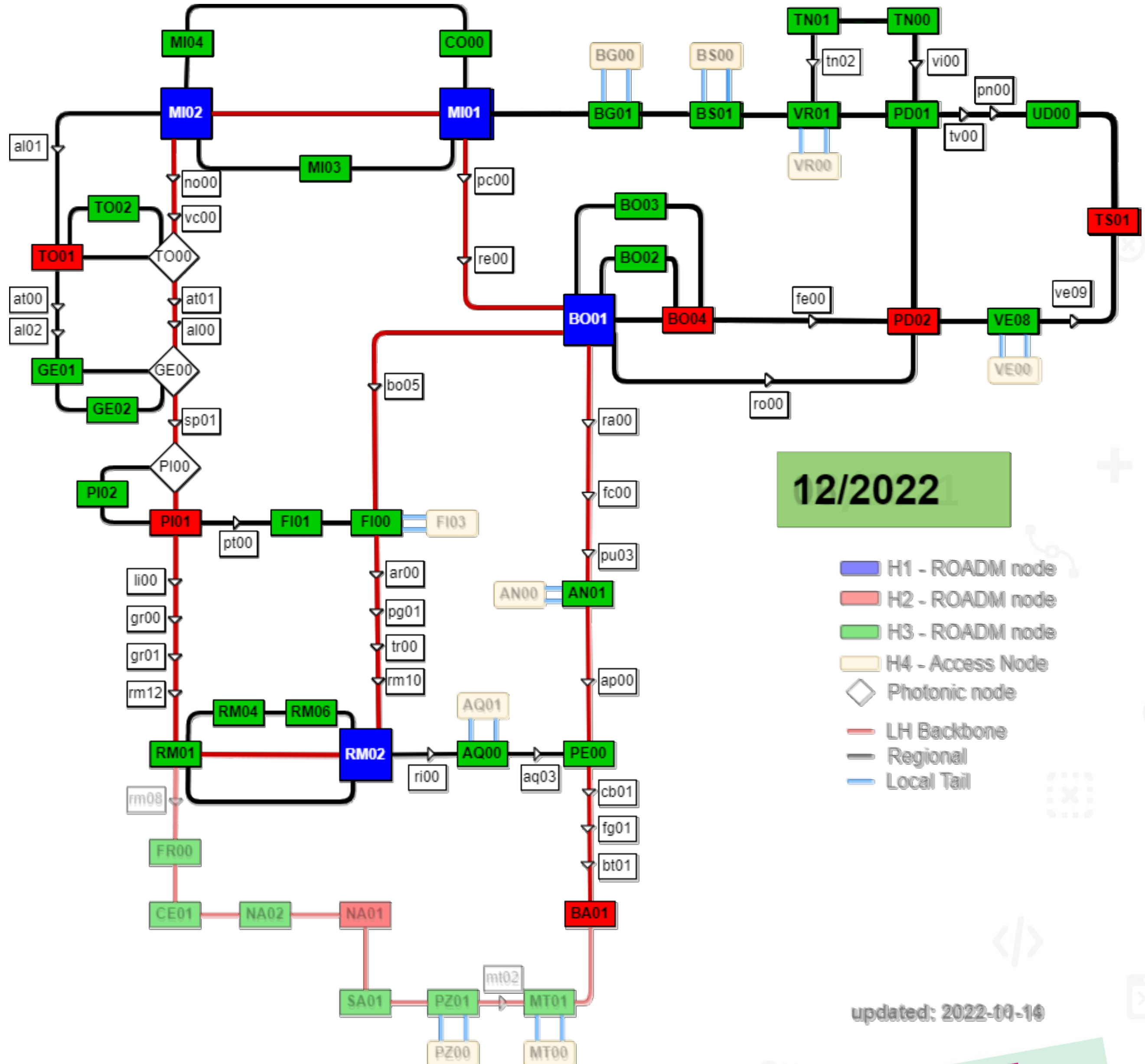
Realizzazione

Avanzamento

- Field Trial
- Fase 1
- Fase 2
- Fase 3
- Fase 4 e 5
- Fase 6 e H4

Gerarchia

H1 - 4 nodi CDC
- H2 - 7 nodi CD
- H3 - 31 nodi C
- H4 - 9 nodi ?



CDC = colorless, directionless, contentionless CD = colorless, directionless C = colorless

Outline

Realizzazione

- Architettura
- Topologia
- Tecnologia
- Avanzamento

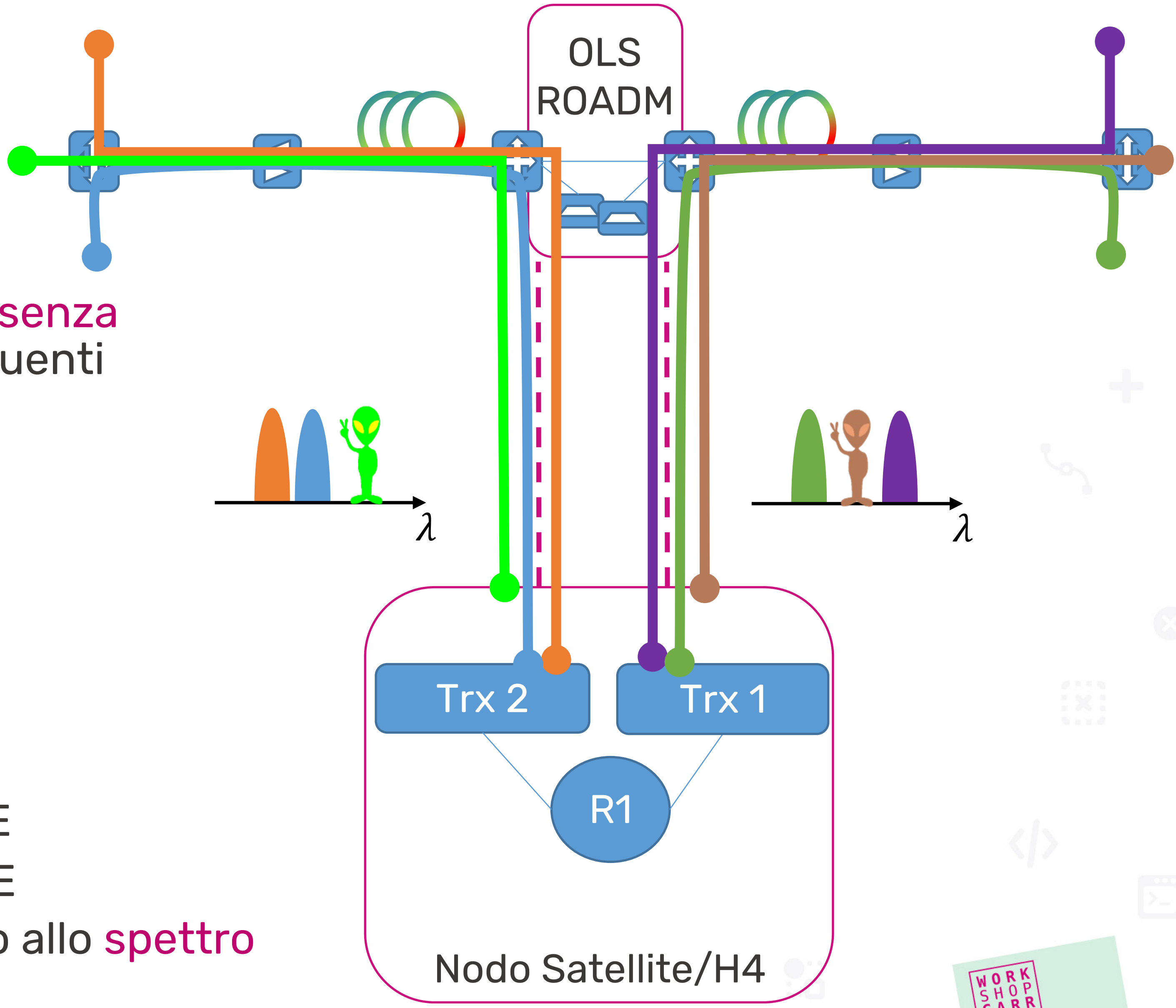
Sviluppi

- Nodi H4 o Satellite
- Spectrum Sharing
- Quantum Key Distribution

Motivazioni

Raggiungere siti senza ROADM con i seguenti requisiti

- Fibre ottiche su doppia via diversificata
- Connettività Est-Ovest
- Servizi offerti:
  - 2x100GbE
  - Nx100GbE
  - + accesso allo spettro

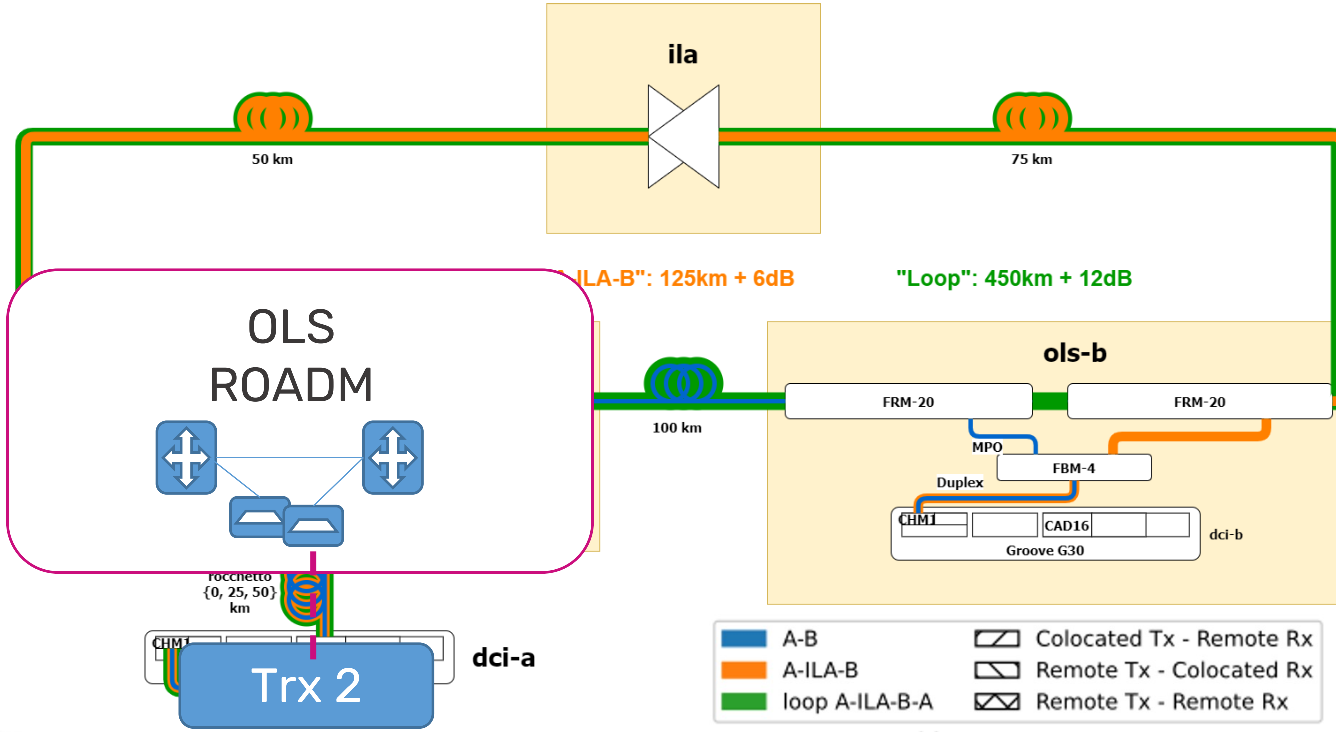


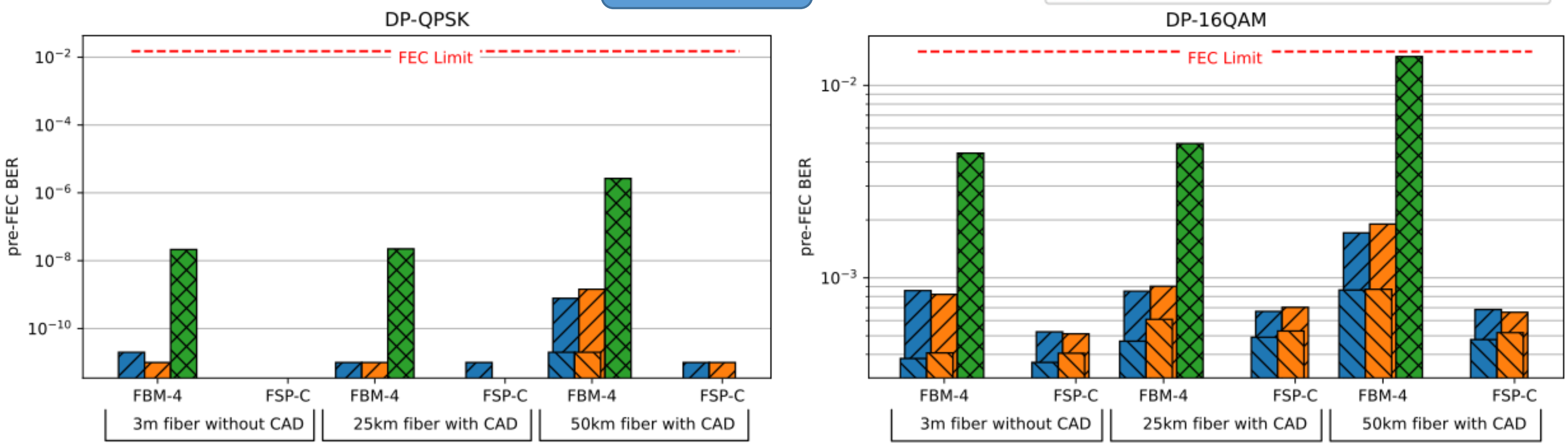
Lab Test

G30 con scheda mux e amp integrati

Set-up

Risultati





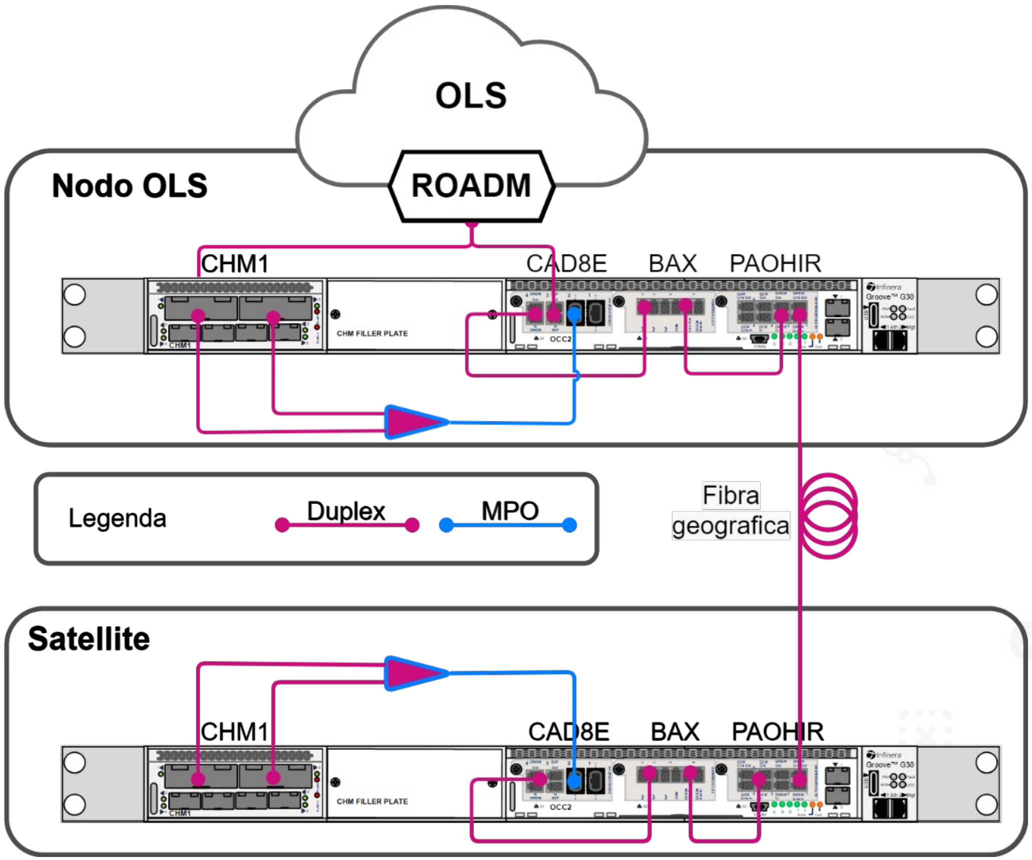
Interconnessione

Nodo OLS e Satellite
per singola via

- Chassis G30
- Colorless (DE)MUX CAD8E
- Booster EDFA BAX
- Preamp EDFA PAOHIR
- Transponder CHM1 [opzionale sul nodo OLS]

Soddisfa requisiti più

- OSC → gestione nodo in assenza di servizi e gain automatico
- MUX in nodo OLS → possibilità di aggiungere trasponder per connessioni singolo span



OLS – Transponder Satellite

Outline

Realizzazione

- Architettura
- Topologia
- Tecnologia
- Avanzamento

Sviluppi

- Nodi Satellite
- Spectrum Sharing
- Quantum Key Distribution

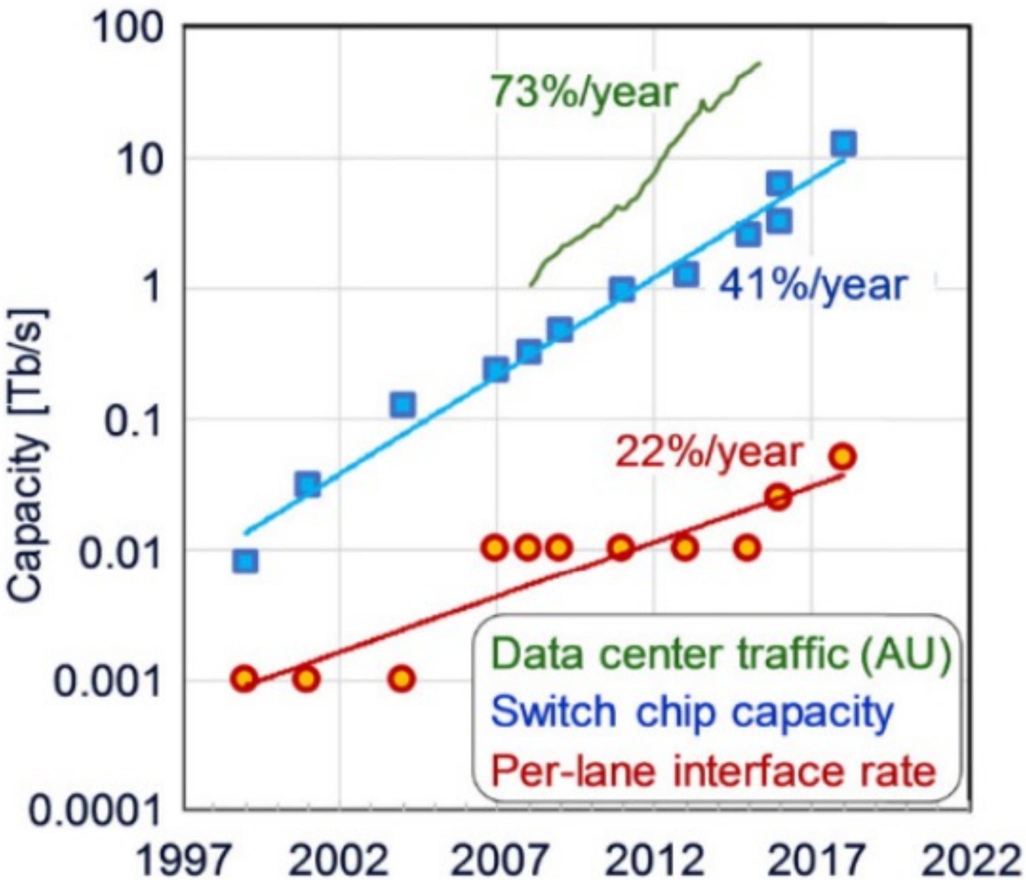
Motivazioni

"It is foreseeable on the 2030s timescale to connect most of the large HEP data centers with dedicated and private multi-Tb/s network links."

Campana, Simone, et al. "HEP computing collaborations for the challenges of the next decade." arXiv preprint arXiv:2203.07237 (14 Mar 2022).

"LHC requirements for Run4 (2027) [...] Larger Tier1s are supposed to get connected to CERN and to their Tier2s at 1 Tbps."

Martelli Edoardo, "Networks for High Energy Physics: LHCOPN and LHCONE", AmRP Working Group Meeting (24 Sept 2021)

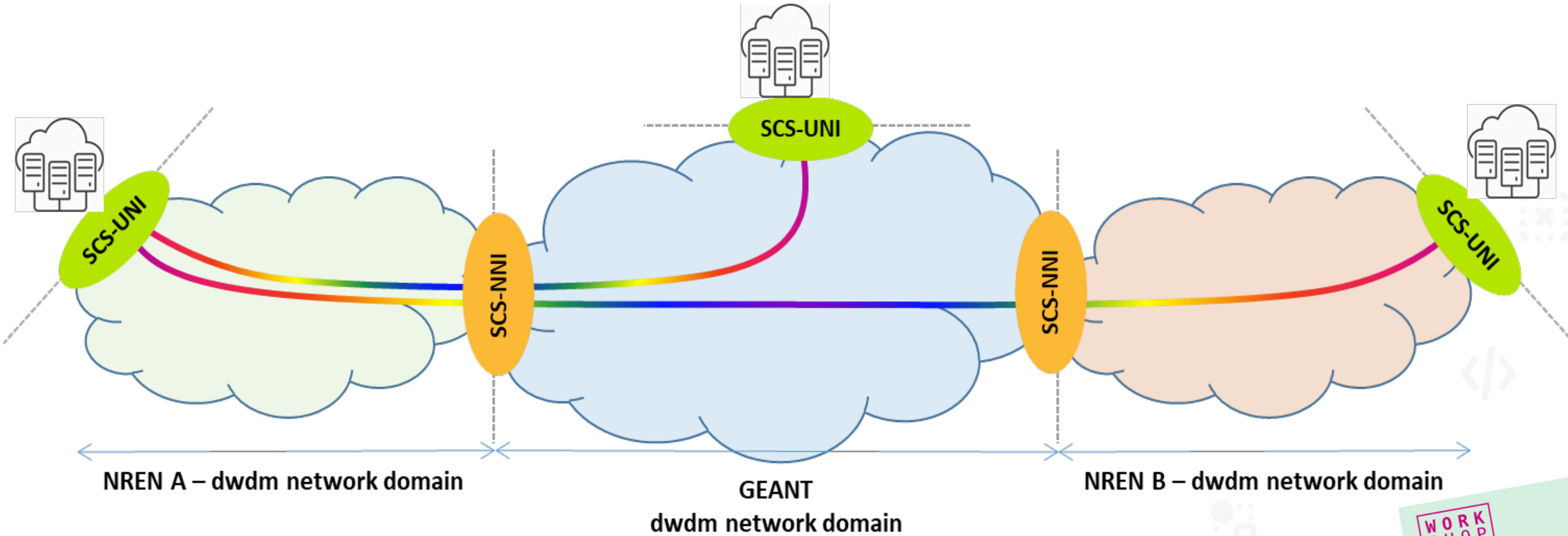


Peter J. Winzer, David T. Neilson, and Andrew R. Chraplyvy, "Fiber-optic transmission and networking: the previous 20 and the next 20 years [Invited]," Opt. Express 26, 24190-24239 (2018)

OLS aperto a 'qualsiasi' segnale unidirezionale e amplificabile

Opportunità

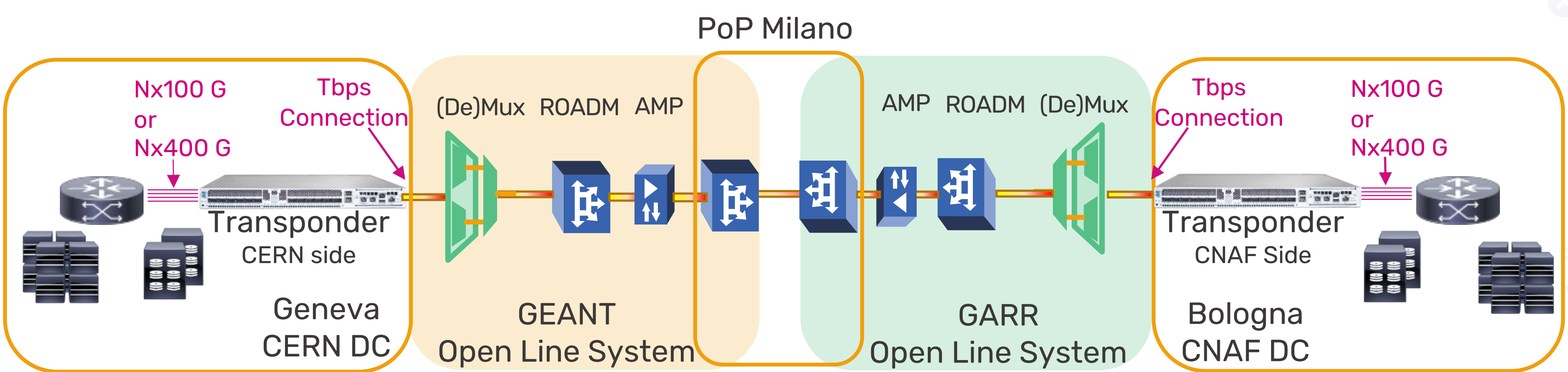
- Costi
  - meno interfacce router e conversioni optoelettriche
- Tempi
  - Risorse condivise già disponibili
  - Ottiche pluggable (OpenZR+, 0dBm, OpenROADM)
- Allocazione dinamica e su richiesta
- Modello del servizio definito da WP7-T2 nel Progetto GN4-3 di GEANT con il nome Spectrum Connection Service (SCS)



Progetto Pilota CNAF-CERN

- Partito 2021Q4
- ~ 1000km fibra
- CNAF DC colocato PoP BO01
- CERN DC colocato PoP Ginevra
- NNI in PoP MI01
- Hardware per sito
  - 2xchassis G30
  - 2xCHM2T
  - 2x100GbE + 1x400GbE

- Passi
  - Acquisto ✅
  - Installazione
    ✅ Bologna ⬜ Ginevra
  - Cablaggi
    ✅ Bologna ✅ Milano ⬜ Ginevra
  - Configurazione OLS e Trx
    ✅ GARR e CNAF ⬜ GEANT e CERN
  - Performance Test ⬜



Outline

Realizzazione

- Architettura
- Topologia
- Tecnologia
- Avanzamento

Sviluppi

- Nodi Satellite
- Spectrum Sharing
- Quantum Key Distribution

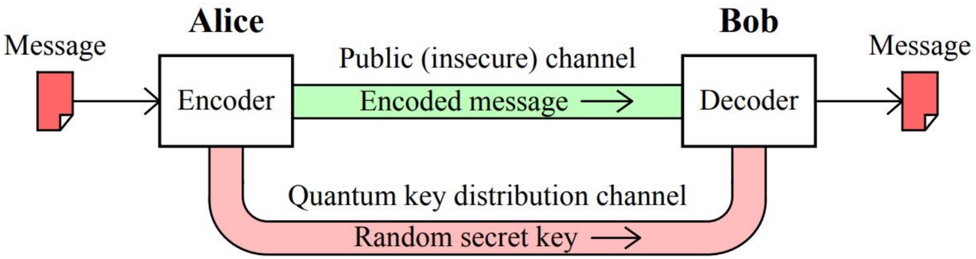
Motivazioni

- Criptografia pre-quantum si basa sulla limitata potenza di calcolo
- Dati di oggi vulnerabili in futuro a nuovi algoritmi e/o tecnologie (e.g. quantum computer e algoritmo di Shor)
- Due approcci
  1. Nuovi algoritmi difficili anche per computer quantistici (e.g. USA NIST quantum-resistant algorithms)
  2. Quantum Key Distribution (QKD): sicurezza garantita da leggi fisiche (non-cloning theorem)

NIST Announces First Four Quantum-Resistant Cryptographic Algorithms

Federal agency reveals the first group of winners from its six-year competition.

July 05, 2022



Sperimentazione

- Test bed
  - Fibra ottica ~10km tra PoP PD01 e PD02
  - Canale classico in banda O e ottiche 10Gbps 10km
  - Canale quantistico in bada C
  - Protocollo QKD a singolo fotone e codifica su polarizzazione (BB84)
- Risultati preliminari
  - Secret Key Rate (SKR) medio ~2.31kbps, frame in errore 1.8%
  - SKR medio 477bps, frame in errore 0

Obiettivi e Conclusione

Terabit/s
17.4 Tbps Day0

Programmabilità e Automazione
ONF TAPI, RESTCONF

Capillarità
Siti Satellite

Evoluzione gestione e monitoraggio
Streaming Telemetry, gRPC

Resilienza
≥ 2 direzioni

Evoluzione servizi
SCS, QKD

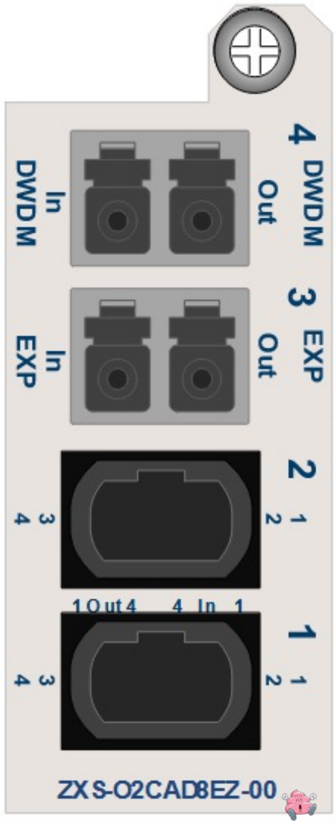
Ottimizzazione uso risorse
Spectrum Sharing

Minore impatto spazi e consumi
×16.5 Gbps/W

Q&A

CAD8E

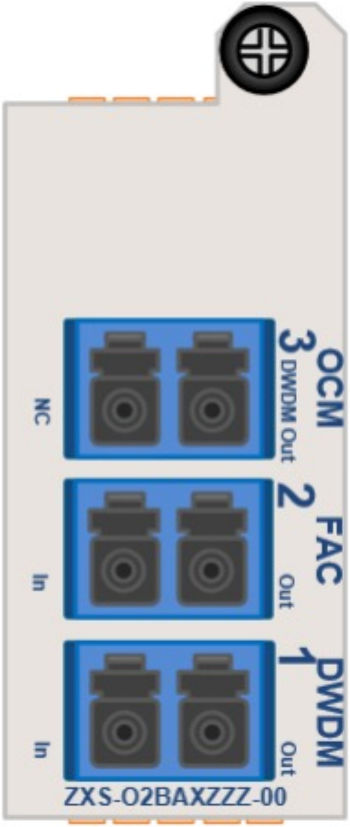
The CAD8E OFP2 works as a colorless 8 channel optical multiplexer or de-multiplexer who can receive DWDM span signal with whichever wavelength (a.k.a. optical power splitter/combiner). The expansion port is coupled to the other 8 fiber pairs through a second 50/50 coupler.



WORKSHOP GARR 2022 NET MAKERS

BAX

The BAX OFP2 (ZXS-O2BAXZZZ-00) is a booster amplifier with extended gain range and line padding VOA. The OFP2 includes one booster EDFA and one passive fiber path for reverse direction. It provides EDFA amplification with an optical supervisory channel. The BAX OFP2 supports fixed and flexible grid up to 96 channels and optical power measurement at the OCM ports. The BAX faceplate includes 3 duplex LC connectors: FAC port for booster input and reverse path output, DWDM port for booster output and reverse path input and OCM port for monitor at EDFA output (one connector unused).



PAOHIR

PAIR OFP2 (81.71T-O2PAOHIR-R) is a multi-channel preamplifier with an optical supervisory channel. It provides EDFA amplifications for up to 96 wavelength channels. PAIR is used in an intermediate range of 0 - 18 dB.

Table 3-15 OFP2 PAxR ports

Ports	Description
DWDM Line In	Receives the multi-channel light signal from the line side.
DWDM Out	Outputs the multi-channel light signal after amplification.
OCM Line In	The optical channel monitor port for the DWDM Line In signal.
OCM Line Out	The optical channel monitor port for the DWDM Line Out signal.
DCM In	Connect to a dispersion compensation module with a pigtail cable.
DCM Out	
DWDM In	Transmit the signal from the input port DWDM In to the output port DWDM Line Out without amplification.
DWDM Line Out